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OTS: 60-31,766

JPRS: 3912

14 September 1960

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- USSR -

by S. I. Katayev

Distributed by:

OFFICE OF TECHNICAL SERVICES
U. S. DEPARTMENT OF COMMERCE
WASHINGTON 25, D. C.
Price: $.50

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

F O R E W O R D

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JPRS: 3912

CSO: 4249-D

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/Following is a translation of an article by S. I. Katayev in the Russian-language Monthly Scientific-Technical Magazine, Organ of the Ministry of Culture USSR, Tekhnika Kino i Televideniya (Television and Cinema Technology), Moscow, No. 6, June 1960, pages 1-8./

(This report was delivered by the author before the All-Union Conference of Radio and Television Broadcast Workers on 8 January 1960.)

The basis of this short analysis of the contemporary state of television broadcast technology is the study of new trends in solving the most important problems of this technology in the field of increasing the size of the territory being served by television, broadcasting, and improving the quality of the television image. It is noted that the use of a cosmic relay station makes it possible to double the frequency band carried on one television channel. This allows the simplification of the diagram of color television, the doubling of the horizontal clearness of the image of monochromatic television sets, and the transmission of a sound track in several languages.

The relation of population to television, both in the Soviet Union and abroad, judging by the demand for television sets, is such that it is hard not to consider them as items of primary necessity.

Last year in the U. S., there were more than forty million television sets, that is, an average of one television set to four persons. Every year the number of television sets increases by several million. It would hardly be an exaggeration to suppose that in approximately ten years there will actually be enough television sets to make the average one for every three persons. This average consumption means that it will be necessary for the Soviet Union in the future decade to have a stock of 70 - 80 million television sets.

Concerning the television broadcasting network, it can be said that in the chief capitalist states, in the next few years no

place will remain which is not reached by signals transmitted by television stations.

A similar task in the Soviet Union appears harder, in view of its large territory. This task means it would be necessary to send a television program to any point in a territory of about 22 million square kilometers. The difficulties of fulfilling this task are furthermore aggravated by the fact that it would not be economically advantageous to make television transmissions to the northern and eastern areas, which have an exceedingly small density of population. However, the task of introducing television programs into all areas of the Soviet Union appears exceedingly urgent.

What is the way to resolve this task?

All existing possibilities of resolving it are expediently divided into three main ways:

(a) creation of a network of district stations united by radio-relay or cable lines;

(b) raising the power of transmitters and setting their antennas for best utilization of distant propagation of wide band ultra short wave signals;

(c) placing an active relay station on a man-made satellite.

The first way was judged by its concreteness, its ease of research, and by the availability of experience and finished models of equipment. However, this means is not economically justified in all cases.

The way mentioned in point b can be divided into two means. One is the use of tropospheric and ionospheric reflectors and radio wave scatterers for the purpose of decreasing the number of intermediate radio-relay stations, but with this means, new difficulties are encountered which complicate attaining a high quality of distant transmission of wideband television signals.

Another means relating to that same point is the utilization of the phenomenon of the anomalous propagation of ultra-short waves for sending television programs directly to individual receivers. This phenomenon owing to its irregularity, it seems, should be investigated rather as serious interference to the task of covering large territories by television broadcasting, than as a useful help in this matter. Cases participating in the irregularity of distant reception of television centers witness to the lowering of expectation of the quality of the reception of signals from a television center on account of interference, even within the limits of its normal radius of action. Interferences of this type are growing with the increase of the number of television centers. In the world at present, there are more than one thousand television radio broadcasting transmitters, and this number is growing without interruption, together with the growth of power of the transmitters. For this reason, interferences of some television centers with the

reception of others increases without interruption.

It is well known that the probability of a hit of signals of the interfering station on the receiver is directly proportional to the angle in whose borders the diagram of the direction of the receiving antenna on the horizontal surface was enclosed. For this reason, one of the ways of lessening the danger of interference caused by cases of anomalous propagation of ultra-short waves at present is the conversion to use of waves of the microwave band range on which it is easier to get the direction of the receiving antenna, and cases of distant propagation are less frequent. But in the field of these shorter waves, unfortunately the shielding effect of buildings, groups of trees, and obstacles in the path of radio wave propagation are more strongly pronounced.

In connection with economic and technical difficulties, cited above, of performing the task of covering large territories, described by the methods above, the outlook for utilization of artificial reflectors and active radio relay stations for television is gaining increasingly more attention from the specialists.

The idea of the practical use of mounts supported at a great height above the earth by force of inertia alone attracted the thought of research specialists even a long time before the perfection of the first artificial satellites. The desire of using artificial satellites for radio connection has been shown by Soviet and foreign authors [1, 6].

Two essentially different alternatives are possible for resolving this problem:

(a) use of passive cosmic reflectors, and

(b) use of active cosmic relays.

In the U.S.A., they are trying to use big balloons with diameters up to 30 meters, made of a thin plastic and covered with a metal coating for increasing the capability of reflecting radio waves for passive reflectors. These balloons are launched in circular orbits with help of rockets and are sent in circular orbits comparatively close to the earth's surface (50 - 3000 kilometers) in special containers, and then they are inflated to the necessary size there by water steam.

The calculations cited by Pirs and Kompfner [4] show that by using radio stations with a power of about 80 kilowatts, and precisely directed receiving and transmitting antennas reflected from these balloons, the signals can be received on earth with the aid of radio receivers equipped with molecular amplifiers, if there is a sufficiently good ratio of signals to noise. This presents the prospect of realization of a multi-channel telephone and telegraph link at intercontinental distances.

By further raising the power of the transmitting stations and improving the quality of reflectors, it would be possible by the very same way to transmit television programs between similarly

equipped television centers set at an interval of several thousand kilometers.

In order to make the link between the transmitting and receiving station reliable enough that the reflecting balloons that are in constant and irregular movement, the number of balloons simultaneously rotating around the earth should be big enough. The calculation of the probability that, within the limits of optic visibility, of the two points circulated at 3.3 thousand kilometers, the fact that only one of these balloons would be visible shows that for maintaining contact 99% of the time (1% interruption), it is necessary to have about 30 such balloons.

Among foreign sources, it is noted that even in spite of relatively high cost of the yearly expense of replacing such balloons, this system of communication offers not only technical but also economic advantages in comparison to radio relay lines.

For the purpose of simplifying transmitting and receiving antennas, sending balloons in a circular orbit along the equator on which the satellite makes one revolution around the earth in 24 hours, is also being investigated. Being released into the side of the earth's rotation, such a satellite can be seen from the earth like an immovable star. The height of this orbit above sea level is about 36,000 kilometers.

The basic advantage of this disposition of the radio wave reflector just on this orbit consists of the fact that, with this method, the number of balloons necessary is decreased 30 times. Interruption of communications on account of having a determined probability of the moments of absence of such reflectors in the zone of visibility of both correspondents are excluded. The main thing is that with this method all ground antennas, both the receiving and transmitting ones, can be made immovable and therefore simpler.

However, in conformity with television radio broadcasting, it is considerably more effective to decide to propose to send into a stationary orbit an artificial satellite carrying a sufficiently powerful relay station for itself with independant sources of solar electrical supply and giro-stabilizing devices guaranteeing the necessary orientation of the receiving and transmitting antennas. In this case, transmission of television power of the transmitter installed on the relay station should be within the limits of from one to several hundred watts.

The first of these figures applies to the case of applying special interference-resistant kinds of transmitter modulation for the reception of these transmissions on a big expensive antenna and for use of molecular amplifiers in the receiver.

The second figure applies to the case of reception on an almost conventional radio broadcast television set, equipped with directional antennas of moderate complexity and cost. In this

second case, is meant the application of antennas of comparatively high directional sensibility which allow directing all its improved high quality energy to the given territory, for example, that occupied by three-fourths of the time belts in the Soviet Union (Figures 2 and 3).

Three transmitters located at three points on the orbit would guarantee the transmission of television programs between any two television centers.

The second of the cases mentioned above is significantly more difficult in its technical completion. This possibility means a more remote outlook for starting world-wide television broadcasting, that is, such broadcasting with which any owner of a television set equipped with several complicated antennas could pick up the transmission of any television center on his set.

At present, it is hard to determine the time required for resolving these tasks. It is well known, however, that the alternative of balloons of 30 meters diameter and the alternative with low power active cosmic relays, which are still not of the comparatively narrow band type, are at present already undergoing experimental research in the U.S.A. (Figure 4). Various foreign institutions and firms are planning the release of active television relay stations in a stationary orbit in the period between 1962 and 1968.

The startling tempo of the development of the technique of release of heavy satellites demonstrated not long ago by Soviet scientists, made known to the whole world by surveying the back side of the moon, the possibility of compulsory orientation of the satellite in space, and by the wide possibilities of contemporary radio technology bear witness to the probability of shortening the periods mentioned above.

Projects are evolving for realizing world-wide television broadcasting with the aid of three satellites set in stationary orbits with the pattern for directional transmitting antennas lying within the limits of 16°. In the case of such a wide diagram of directional transmitting antennas, ten times more power is needed for the transmitter, than the power necessary for serving the territory encompassed by one state. However, this cannot constitute an unsurmountable obstacle to realizing such a relay in the future when releasing multi-ton satellites into stationary orbit will be successful.

Apparently, already toward the end of the present decade, and possibly considerably sooner, world-wide television broadcasting with the aid of cosmic radio relays will be a common feature.

One of the most important methods of raising the technical qualities of television transmission could be the conversion to color television. However, experience in the U.S.A. shows that introduction of color television on a wide scale encounters a

number of serious difficulties.

In spite of the fact that since the time of the introduction of standard color television in the U.S.A., about seven years ago, the number of color television sets consists of only 1% of all television sets in the U.S.A. The main thing, however, is that there are no signs that this proportion will change radically in the next few years.

Apparently, considering everything in the U.S.A., the combined color system of television was not within the reach of the mass of buyers on account of its costs. Here it is necessary to bear in mind that not only the cost of the television set itself, which is still just about three times as expensive as the monochromatic television set, but also that of the cost of operation is considerably higher than that of the monochromatic one.

If this system of color television is considered, then it is also necessary to consider that there is no more substantial way of radically reducing the cost price of the television set than by rationalising and automatising the methods of producing all basic elements of the television set. The search for new methods of technology, however, is a rather long process, which does not guarantee the achievement of large scale successes. From this consideration comes the conclusion that it is necessary to continue the persistent search for new, more economical systems of color television, that is, such systems for which the cost of a color television receiver would not be much higher than the cost of a monochromatic receiver.

Inasmuch as monochromatic television is continuing to develop intensively, it is necessary to further perfect primarily those of its qualities which still leave it in an unfavorable situation in comparison to the cinema.

The application of more highly perfected electronic optics and more effective white phosphor tubes offers the necessary increase in the brightness and clearness of the image. Using a great number of types of picture tubes of smoked glass affords a noticeable increase in image contrast.

Transparent screens and flat tubes are being studied and developed in which the increase in contrast may be gained without substantially decreasing brightness. In this relation, there are definite prospects of attaining results like those that cinema technology affords. A gradual increase in the screen diagonal leads toward a deepening of the television set, that is, whose size is measured in the direction perpendicular to the screen. By using tubes with a 110-120° scanning angle, this condition has become more unified, but by using flat tubes, it will be 3 - 4 times more unified.

The conversion of the cinema to the wide screen presents a similar problem as that facing television. Apparently, there will

be success in finding a solution that offers the possibility of receiving wide screen films on conventional television sets.

In connection with the rising demands of viewers for clearness in the television image and with the appearance of transmitting and receiving tubes with a clearness of more than one-thousand lines, (in the literature, there are notices of creation of picture tubes guaranteeing a clearness up to 5,000 lines) there arises the possibility of considerably increasing the clearness of the image.

In our journal, one of these possible means for considerably increasing the clearness under conditions of widening the frequency band of the video channel by two times /57 has already been mentioned.

Such a widening of the band in the limits of the band range encounters almost undeterminable difficulties of an economic and organization-technical character. More possibilities are offered in this relation in the microwave band range, however, on account of the necessity of building a great number of stations on a limited territory, similar difficulties arise with this method.

The most favorable possibility for helping solve the problem of freedom from crowding in the band range of very short and micro-waves, appears to be the cosmic relay stations, because in this case the number of transmitters serving a given large area is reduced by several times. Together with this, they limit the required number of wide-band channels set aside for television, which offers the substantial possibility of widening the frequency bands of each separate channel. By the same token, the use of cosmic relay stations permits an increase in clearness of monochromatic television on account of the rise in horizontal brightness (for example, with a channel band of 14 Megacycles) approximately to 1,000 lines; that is, almost to the clearness of the cinema, and remarkably simplifies and cuts the cost of color television receivers without damaging the quality of the color image.

The essence of this method of simplifying the color television receiver consists in rejecting the use at present of channel frequency division multiplex obtained by use of quadrature modulation of color subcarriers and interlacing of spectrums of brightness and the color signal. Instead of this, in the simplified system, color information sustains the spectrum of signal brightness, as shown in Figure 5. Under these conditions, the diagram of the receiver is substantially simplified, if the cost of the tubes is not considered. The lowering of the tube price is to be sought in the field of rationalization of technology, which, with the simplified principal of decoding color information, leads in this case to the addition to the conventional plan of the monochromatic television receiver of only the two band filters 4 and 5 (Figure 6), of the two detectors 6 and 7 and of the uncomplicated

matrix converter 2, the prospect is achieved of not only lowering the cost of the receiver, but at the same time of improving the quality of the color image, as well as simplifying the operation of color television sets.

The line of resistance necessary for improving the lag is obtained by filters 4 and 5; in this case they can be completely dependant on the equipment of the television center, which still further simplifies the receiver.

In the simplified diagram of color television, illustrated in Figure 6, the diagram of the differential (developing) amplification regulator 8 will oscillate the level of color signal information unequally in comparison to the oscillations of the signal level on such a wide band as 14 megacycles, on account of the especially distant diffusion of the ultra-short waves. The question of the necessity of this plan in the case of the use of a cosmic relay station, however, is still subject to the experimental explanation, because the condition of passing the radio signal around a sharp angle through the atmosphere can be further facilitated than passing these signals in the troposphere parallel to the earth's surface. Therefore, it is not dismissed that this diagram is not entirely necessary in using the cosmic relay station.

The increase of the size of the territory in which, in the near future, transmission of major television centers of various countries can be received also emphasizes the question of simultaneous transmission of the sound track of television in several languages at the same time. This consideration arises, at present, if a new technical problem is not to be presented in effective new technical decisions. According to all signs, it is not far off that universal receivers will be required on which the viewer can choose the accompanying language at will. Nevertheless, the deciding fate of such television programs could possibly be made by finding a sufficiently wide circle of users.

The question has several means of technical solutions. For example, latitudinal phase pulse modulation transmitted during the reverse course of the horizontal sweep and auxilliary sound carriers and others could be used.

If such requirements for quality of sound reproduction, which are usually required for the sound track of television transmission, are to be claimed for these auxilliary sound channels, and at the same time considering the prospect of raising the image clarity on account of the possibility of using wider frequency bands for realizing cosmic relay stations in the future, then, apparently the use of several FM channels whose bands can be arranged as shown in Figure 5, will be more suitable for the purpose of transmitting alternative sound tracks.

The magnetic recording of television programs, in line with

the recording of movie films, is being used more and more. In a number of large foreign stations, all television transmissions are made exclusively by recording which permits a better version of stage transmissions, and which is also the necessary way to supply it with the necessary report commentaries for transmission. This also permits the complete separation in the territorial and administrative relations of the production of television programs from the tasks undertaken by television stations.

In the equipment studied, the tendency of successful use of vidicons gained from more complex tubes was observed in all new positions.

The creation of devices for the replacement of studio background decoration by movie film recordings, promise the prospect of considerable enrichment of the quality of studio transmissions, as well as economy in studio space, and the costs of stage equipment.

Semi-conductor television sets have appeared, permitting an economy of electrical energy of 8 to 10 times in comparison with tube television sets, and, at the same time, increasing the useful life of the television set.

Considering the huge economic effect of replacement of tubes in television sets by transistors, it is necessary to consider this problem one of the basic trends of the contemporary technology of building economical television receivers in the near future /7/.

This account testifies both to the great possibilities of the further expansion of territory served by television and to the existance of a number of concrete ways for considerably improving its quality attributes.

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FIGURE ARTICLE

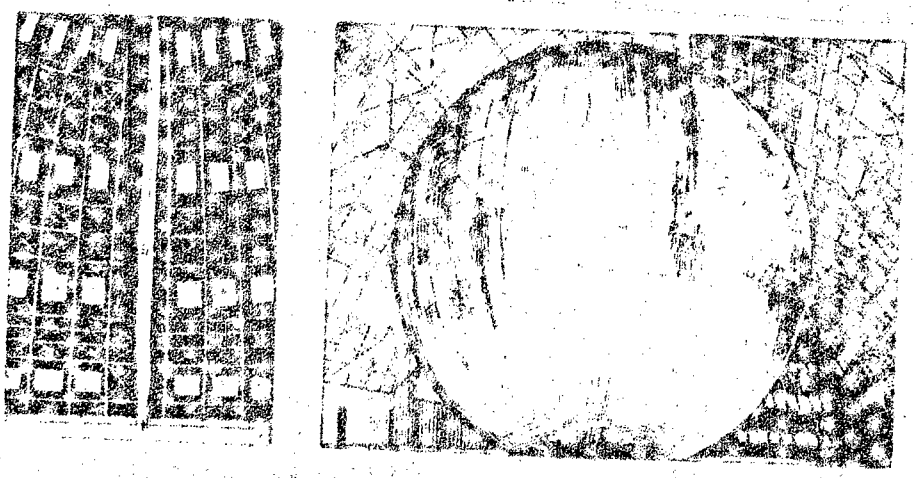

Figure 1. Passive Reflector. Plastic Balloon. Left: detail view. Right: expanded view.

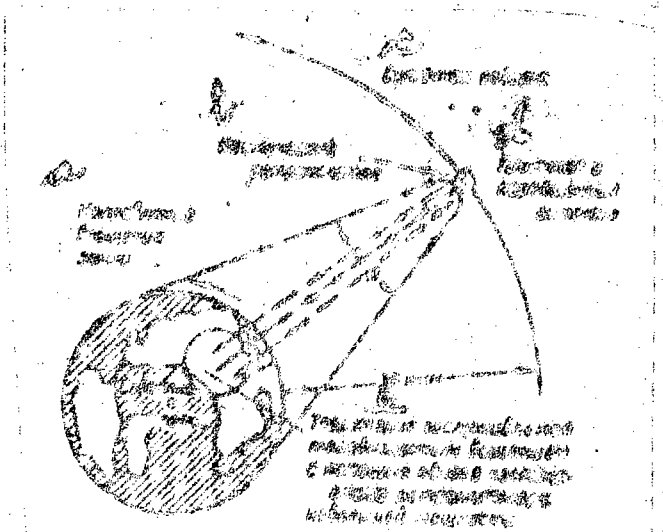

Figure 2. Operation of a television of limited scope of territory with the power of an active relay station in stationary orbit. (a) direction of earth's rotation; (b) cosmic relay station; (c) daily orbit; (d) receiving and transmitting antennas; (e) territory served by television broadcast with the aid of a low power relay station.

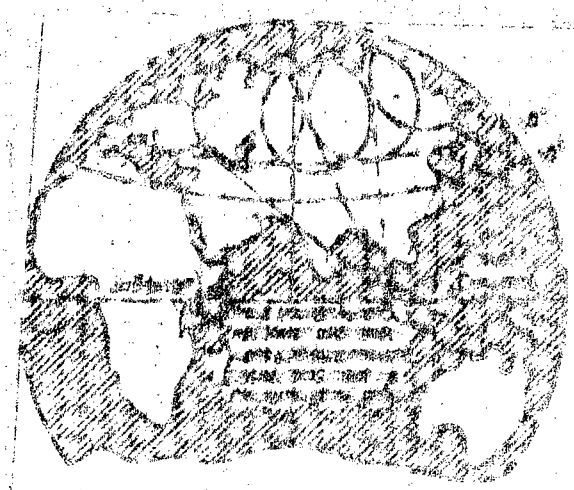

Figure 3. Selection of a location for the relay station on the stationary orbit and in possible areas of subsequent television servicing of the territory of the U.S.S.R. (a) point of central projection of the remote relay station put in stationary orbit.

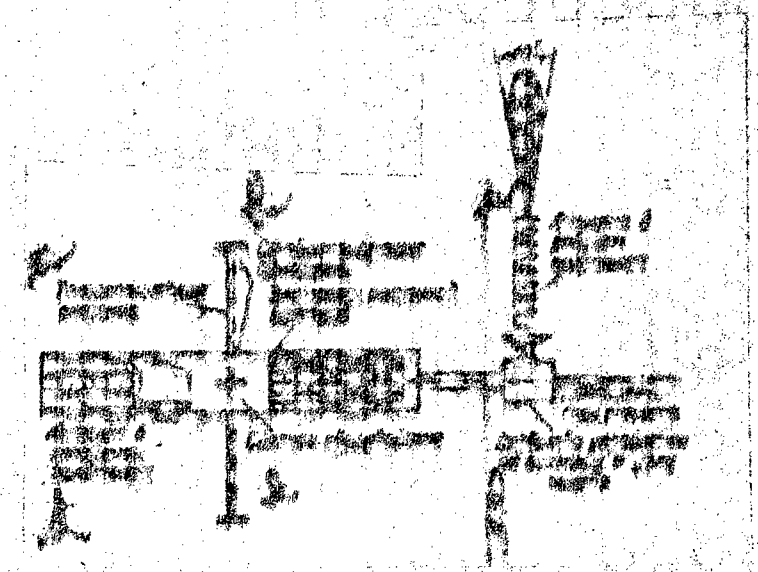

Figure 4. Remote relay station according to the plan of the Space Electronics Corp.
(a) telescope antenna; (b) stabilizing motors - solar battery elements; (c) antenna in operating position; (d) antenna in inoperative position; (e) attached equipment; (f) telescope antenna. Means for guiding according to Azumth and Place angle.

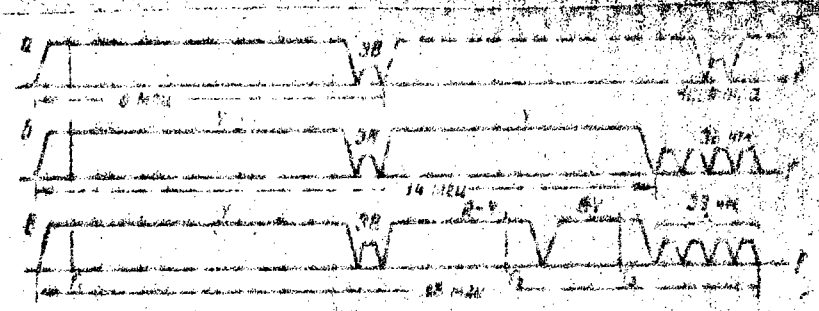

Figure 5. The question of widening the frequency bands satisfying the principle of compatibility.
(a) band arranged by existing standards;
(b) arrangement of spectrums according to information of brightness of one widened channel and five FM channels of sound accompaniment (or FM sound broadcast); (c) arrangement of spectrums of brightness and color signals using simplified color television receivers.
Note 5 (b): In the video track of the receiver, in this case, it is provided that one normal sound FM channel except into the widened video frequency band should be eliminated.

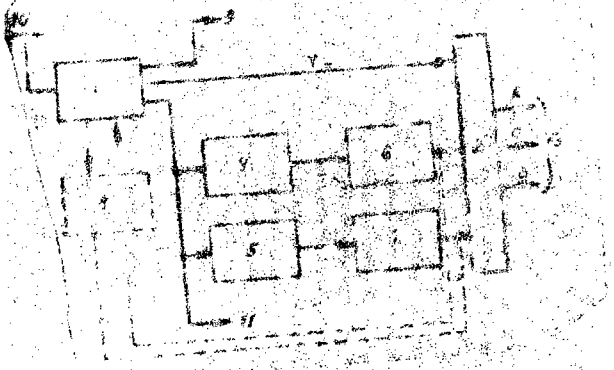

Figure 6. Simplified diagram of the color television receiver used for forwarding color information beyond the brightness spectrum of the signal.
(1) video-and radio receiver; (2) matrix converter; (3) for color three-projector picture tube or three-projector monochromatic picture tubes; (4) filter for the red signal; (5) filter for the blue signal; (6 and 7) detectors for red and blue signals; (8) diagram of differential (frequency tuning) AFC; (9) loudspeaker; (10) antenna.

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